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ISLAND CONSTRAINTS AT EIGHTY*

Sue Kemper and coworkers at the University of Kansas have documented marked age-related declines in the complexity of adults' language. Studies of adults' diary entries (Kemper, 1987a) reveal age-related declines in the complexity of elderly adults' written language (cf. Figures 1—3). Elderly adults are significantly less likely to use complex structures such as multiply embedded sentences, THAT- and WH-clauses, gerunds, and participles. The age-related declines in the frequency of embedded clauses are more severe in subject position than in predicate position — suggesting a marked decline in the adults' ability to process left-branching structures.

Kemper has replicated these findings across a number of different modalities using a number of different measures. Table I (Kemper et al., 1989) demonstrates adults' age-related declines in an oral question-answering task, oral statements and written statements. As shown in Table I, there is no evidence that the adults' linguistic abilities in any way reflect their level of education or vocabulary size. The similar declines across modalities and across tasks suggest that elderly adults may literally be losing their capacity to communicate. At the very least, adults over 74 should probably refrain from making grammaticality judgements for linguists.

These declines in syntactic complexity appear to be related to an age-related decline in working memory. Kemper et al. (1989) report that the mean number of clauses per utterance (MCU), a general measure of the complexity of adults' language, and the incidence of left-branching sentences are positively correlated with the adults' backward digit span using the Wechsler Adult Intelligence Test — Revised (WAIS) subtest (Wechsler, 1958). Further, Kemper and Rash (1988)

Helen Goodluck and Michael Rochemont (eds.), Island Constraints, 351—372.

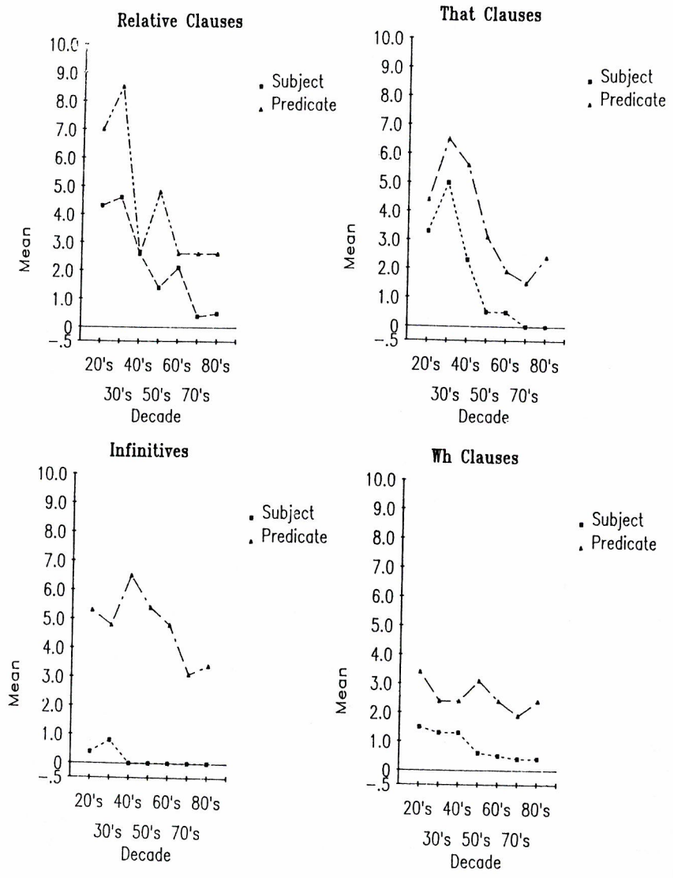

Fig. 1. Frequency of relative clauses, that-clauses, infinitives, and wh-clauses in subjects (S) or predicates (P). (Adapted from Kemper, 1988). *Note*: from *Language, Memory, and Aging* (p. 70) by L. Light and D. Burke (eds.), 1988. New York: Cambridge University Press. Copyright © 1988 by Cambridge University Press. Reprinted by permission.

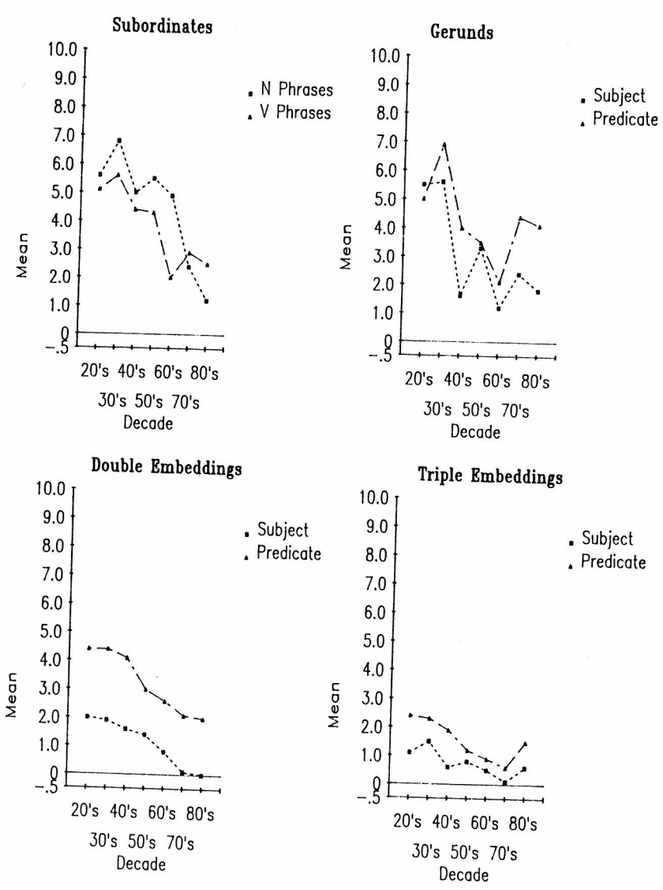

Fig. 2. Frequency of subordinates, gerunds, double embeddings and triple embeddings in subjects (S) or predicates (P). (Adapted from Kemper, 1988). *Note*: from *Language, Memory, and Aging* (p. 71) by L. Light and D. Burke (eds.), 1988. New York: Cambridge University Press. Copyright © 1988 by Cambridge University Press. Reprinted by permission.

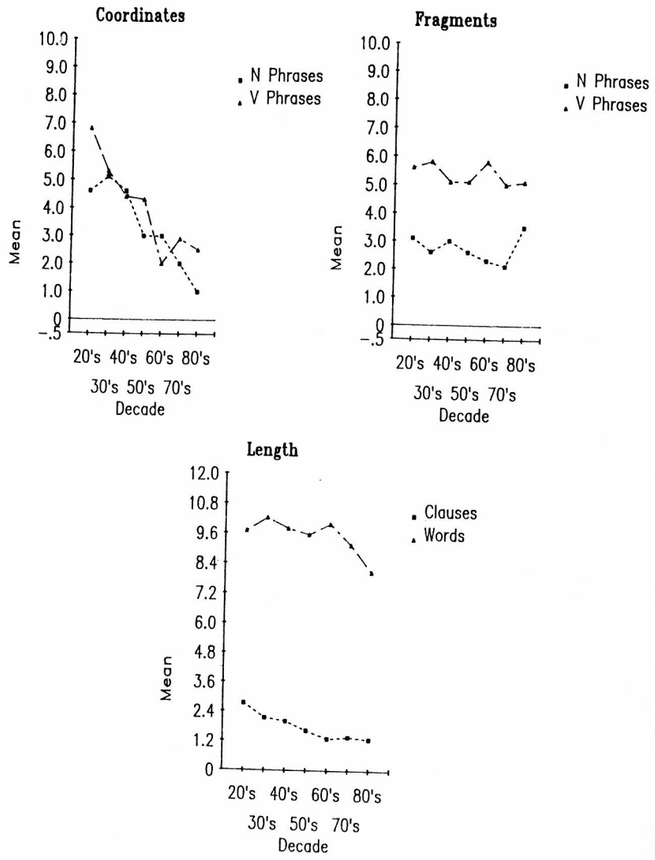

Fig. 3. Frequency of subject (S) or predicate (P) coordinates, noun phrase (NP) or verb phrase (VP) fragments and mean clause length and mean sentence length. (Adapted from Kemper, 1988). *Note*: from *Language, Memory, and Aging* (p. 72) by L. Light and D. Burke (eds.), 1988. New York: Cambridge University Press Copyright. © 1988 by Cambridge University Press. Reprinted by permission.

TABLE I

Age-related decline in the Mean Number of Clauses per utterance and the incidence of left-branching clauses in adults' oral question-answering, oral statements, and written statements and their correlation with measures of WAIS digit span and vocabulary and the adults' education.

Complexity measures:

	College	60s	70s	80+
Mean Clauses per Utterance				
Oral question-answering	1.2	1.2	1.2	1.2
Oral statement	1.6	1.3	1.4	1.3
Written Statement	2.6	2.1	2.1	1.8
Left-Branches per Utterance				
Oral question-answering	6%	4%	3%	3%
Oral statement	10	4	4	3
Written statement	13	9	5	3

Partial correlations removing effect of age:

	Education	Vocabulary	Forward	Backward
MCU	−0.02	+0.23*	+0.27**	+0.22*
Left-Branching	−0.02	+0.16	+0.46**	+0.49**

* $p < 0.05$, ** $p < 0.01$

From: Kemper, S., Kynette, D., Rash, S., O'Brien, and Sprott, R. (1989).

calculated Yngve depth (Yngve, 1960), a measure of the working memory demands of sentences, and found that it was positively correlated with WAIS digit span, MCU, and the incidence of left-branching sentences. Complex sentences, in general, and left-branching sentences, in particular, are difficult to produce because the multiple syntactic constituents must be held in memory simultaneously.

The effects of working memory limitations appear to be general, affecting elderly adults' processing of complex structures as well as their production of complex sentences. Kemper (1986) showed that while middle-aged adults in their 30s and 40s have no difficulty imitating left-branching sentences, elderly adults in their 70s and 80s produce many

abridgements and other distortions of left-branching sentences, especially when the embedded clause is rather long. In contrast, middle-aged and elderly adults alike are able to correctly imitate or paraphrase right-branching sentences regardless of the length of the embedded clause. Elderly adults' recall of propositional information shows a similar effect of branching direction in that elderly adults recall significantly less information from left-branching clauses than from right-branching clauses whereas middle-aged adults' recall is not affected by branching direction (Kemper, 1987b).

Such extensive declines in sentence processing abilities raise the question of whether elderly adults merely lose their capacity to process sentences or whether they undergo irreversable changes to the structure of their grammatical system. Do such declines represent an inverse of the process of acquiring language (as suggested for the phonological system by Jakobson, 1968), or is the process strictly a degradation in the linguistic performance of elderly adults? It is possible that language-specific grammars, residing in the minds of real individuals, are psychologically active — requiring constant updating from linguistic structures in their environment. Severe changes in processing ability could lead to marked changes in linguistic competence such as a resetting of various syntactic parameters to a null position (cf. Roeper and Williams, 1987). Even if linguistic competence resides in a more permanant form, it is possible that age-related changes in working memory might affect adults' ability to retain grammatical constituents in memory long enough to detect grammatical rule violations. Thus, it is worth investigating whether any changes in linguistic competence are detectable among the wide array of processing deficits.

We decided it would be interesting, in this context, to examine whether elderly adults suffer a breakdown or loss of island constraints. Current linguistic theory has attempted to find a general explanation for such constraints in terms of global constraints on rules (Chomsky, 1977, 1981). Such constraints apply to a wide range of syntactic structures. Our hope was that this would make it possible to determine whether elderly adults had completely lost all knowledge of these syntactic constraints or merely had difficulty processing specific sentences embodying the constraints. If they had lost the constraint completely they should perform at random levels across all example sentences, whereas if they were just experiencing difficulties processing

various syntactic constructions, they might perform poorly on some examples, but above chance levels on others.

We prepared test booklets for presentation to the subjects. A previous experiment (Kemper et al., 1989) had shown that the presentation modality did not affect test results. The written test contained a total of 192 sentences. There were three primary types of sentences: 1. anaphoric sentences involving reflexive, passive and subject-raising sentences (48 sentences); 2. WH-sentences involving WH-questions, relative clause sentences and topicalized sentences (48 sentences); and 3. gapless relative clause sentences involving left- and right-branching sentences (48 sentences). A variety of other grammatical and ungrammatical sentences (48 sentences) were also included to provide baseline information (see Tables II—V, below).

The anaphoric sentences tested whether the adults were sensitive to constraints regulating the use of reflexives, passivization, and subject-raising. We tested two constraints: the tensed-S constraint and the specified-subject constraint. The tensed-S constraint blocks reflexives, passives and subject-raising in embedded clauses containing tensed verbs (cf. Chomsky, 1981). For example, the tensed-S contraint accounts for the ungrammaticality of the sentence "*The woman believes herself is right." The grammatical version of this sentence contains an infinitival form of the verb in the embedded clause, e.g., "The woman believes herself to be right." The specified-subject constraint ensures that only the subject of the embedded sentence can serve as the antecedent of the reflexive, be passivized, or undergo subject-raising. The specified-subject constraint accounts for the ungrammaticality of sentences with raised objects, e.g., "*John is expected the woman to help." The grammatical version of this sentence would require raising to occur from the subject position in the embedded clause, e.g., "John is expected to be helped by the woman." Table II provides examples of our test sentences for the tensed-S constraint and the specified-subject constraint.

Ungrammatical sentences were created by violating either constraint. Thus, for the tensed-S constraint, the ungrammatical sentences used a reflexive in a tensed clause, passivized a tensed clause, or raised a subject from a tensed clause. For the specified-subject constraint, the ungrammatical sentences used the object as an antecedent for a reflexive, passivized the object, or raised the object into the main clause. In addition, sentence length was manipulated so as to affect the distance,

TABLE II

Example of the anaphor sentence used in experiment. Material in parentheses was added to create the longer versions of each sentence.

Tensed-S Constraint	
Subject-raising	
Grammatical	The man (in a red and green plaid suit) appears to be running away.
Ungrammatical	*The man (in a red and green plaid suit) appears ran away.
Passive	
Grammatical	The fur (from the old mangy dog) is guaranteed to fly.
Ungrammatical	*The fur (from the old mangy dog) is guaranteed will fly.
Reflexive	
Grammatical	The woman (with the big blue convertible) believes herself to be right.
Ungrammatical	*The woman (with the big blue convertible) believes herself am right.
Specified-Subject Constraint	
Subject-raising	
Grammatical	The man (in the red and green plaid suit) seems to like John.
Ungrammatical	*John seems the man (in the red and green plaid suit) to like.
Passive	
Grammatical	The woman (from the city treasurer's office) is expected to help John.
Ungrammatical	*John is expected the woman (from the city treasurer's office) to help.
Reflexive	
Grammatical	The woman (in the mink hat and jacket) considers herself to have outwitted John.
Ungrammatical	*The woman (in the mink hat and jacket) considers John to have outwitted herself.

in words, between, e.g. the reflexive and its antecedent. Two examples of each type of grammatical and ungrammatical sentence were included on the test. See Table II for examples.

We also tested elderly adults' awareness of two constraints on WH-movement. The 'conjoined-NP' constraint prohibits substituting a WH-word for one conjunct and then fronting just that conjunct to form a question as in "*Whom did you see Mary and?" (cf. Ross, 1967). Second, the 'Complex NP constraint' blocks the movement of a WH-phrase out of a WH-phrase as in "*What have you met the man who invented?" These constraints apply to the formation of WH-questions as well as to the construction of relative clauses and topicalized sentences. As applied to relative clauses, the conjoined-NP constraint requires that all conjuncts be relativized prohibiting "*I just met the bride who the man and were married last week" while the Complex NP constraint blocks relativizing noun phrases which have been extracted from within another relative clause as in "*I bought the radio which you met the man who invented." As applied to topicalized sentences, the conjoined-NP constraint requires that both conjuncts be topicalized to block "*That woman, I know I've seen and Fred" while the Complex NP constraint prohibits topicalizing a noun phrase extracted from within a relative clause as in "*That radio, you've met the man who invented." The length of the critical noun phrase was also manipulated. Two examples of each type of WH-sentence were included on the test. See Table III for examples.

The other types of sentences we used are shown in Tables IV and V. Table IV contains examples of the sentences with gapless relative clauses that we used, while Table V shows examples of the other sentences which appeared on the test. Written test booklets were created by randomly ordering the anaphor sentences, Wh-sentences, relative clause sentences and the rest. Each sentence was accompanied by a seven-point rating scale where '1' = 'ungrammatical, bad English' and '7' = 'grammatical, good English'. The instructions which accompanied the written test included example grammatical and ungrammatical sentences.

68 elderly adults participated in this study. All were members of a research panel recruited from the local community through newspaper advertisements. Each was judged to be a native speaker of English. 47 had participated in another study (Kemper et al., 1987) in which the Vocabulary, Digits Forward, and Digits Backward tests from the

TABLE III

Examples of the WH-sentences used in experiment. Material in parentheses was added to create the longer versions of each sentence.

Conjoined-NP constraint	
Question	
Grammatical	You saw the woman (from the apartment house next door) and whom?
Ungrammatical	*Whom did you see the woman (from the apartment house next door) and?
Relativized	
Grammatical	I just met the bride (in a pink dress) and the groom who were married on Tuesday.
Ungrammatical	*I just met the bride (in a pink dress) and who was married on Tuesday.
Topicalized	
Grammatical	That woman (from the apartment house next door) and Fred, I know I've seen together.
Ungrammatical	*That woman (from the apartment house next door), I know I've seen together and Fred.
Complex NP Constraint	
Question	
Grammatical	You met the man (from your hometown in Indiana) who invented what?
Ungrammatical	*What have you met the man (from your hometown in Indiana) who invented?
Relativized	
Grammatical	I bought the radio that was invented by the man (from your hometown in Indiana) whom you met.
Ungrammatical	*I bought the radio that you met the man (from your hometown in Indiana) who invented.
Topicalized	
Grammatical	The man (from your hometown in Indiana) who invented that radio, you've met.
Ungrammatical	*That radio, you've met the man (from your hometown in Indiana) who invented.

TABLE IV

Examples of the relative clause sentences used in experiment. Phrases or clauses in parentheses were added to create the longer versions of each sentence.

Right-branching	
Object relative	
Grammatical	Mary ate the bread (on the sideboard/sitting on the sideboard) which I baked.
Ungrammatical	*Mary ate the bread (on the sideboard/sitting on the sideboard) which I baked a cake.
Subject relative	
Grammatical	Bill found the book (about Napoleon's battles/that the author had signed) which was lost.
Ungrammatical	*Bill found the book (about Napoleon's battles/that the author had signed) which the present was lost.
Left-branching	
Object relative	
Grammatical	The bread (on the sideboard/sitting on the sideboard) which I baked was eaten by Mary.
Ungrammatical	*The bread (on the sideboard/sitting on the sideboard) which I baked a cake was eaten by Mary.
Subject relative	
Grammatical	The book (about Napoleon's battles/that the author had signed) which was lost was found by Bill.
Ungrammatical	*The book (about Napoleon's battles/that the author had signed) which the present was lost was found by Bill.

TABLE V

Examples of the other types of grammatical and ungrammatical sentences used in experiment. Material in parenthesis was added to create the longer versions of each sentence.

Grammatical	The man (from the city's welfare office) needs to get this job. I know the host of the party invited me.
Ungrammatical	*The man (from the city's welfare office) needs job. *I know the host (of the party) invited.

Wechsler Adult Intelligence Test-Revised (Wechsler, 1958) were administered. Information about the adults' education, employment history, and self-reported assessments of health were also collected. There were 21 adults (16 women) 60 to 69 years (M = 69.7 years), 29 adults (16 women) 70 to 79 years (M = 73.5 years), and 12 adults (10 women) 80 to 93 years (M = 83.3). The elderly adults were paid for their participation.

In addition, a panel of 25 college students was recruited from introductory psychology classes. These college students received course credit for their participation. All were native speakers of English between 17 and 23 years of age.

All of the adults were given written test booklets containing instructions, examples, and the test sentences. The elderly adults were given the booklets and oral instructions at the conclusion of a session testing their prose comprehension. They mailed in their completed booklets after working on them at home. The college students were tested in small groups of 4 to 6 participants.

The ratings from the college students were first analyzed separately with a series of *t*-tests to ensure that the sentences were actually grammatical and ungrammatical as intended. The college students were able to distinguish grammatical from ungrammatical sentences of all types, $t(23) = 19.27$, $p < 0.01$. However, the college students found some of the grammatical sentences to be less acceptable than others. The longer versions of the anaphor sentences (M = 5.7) were judged to be less grammatical than the short versions (M = 6.5), $t(23) = 7.28$, $p < 0.01$. Subject-raising, passive, and reflexive sentences were judged to be equally grammatical, all $p > 0.50$.

The longer versions of the WH-sentences (M = 4.2) were rated as less grammatical than the short versions (M = 5.1), $t(23) = 1.58$, $p < 0.05$, and the topicalized sentences (M = 4.5) were judged to be significantly less grammatical than the question (M = 5.2) and relative clause sentences (M = 5.7), both $t(23) > 2.3$, $p < 0.05$. Indeed, the college students judged long topicalized sentences to be ungrammatical, giving them a mean rating of 3.4 on the 7-point scale.

Age-group differences in rated grammaticality were then investigated with a series of ANOVAs contrasting the ratings from the college students and the elderly adults. The ratings for the anaphor sentences, WH-sentences, and other grammatical and ungrammatical sentences were analyzed separately. Mean grammatical ratings were obtained by averaging the ratings assigned to the individual sentences of each type. All sentences which were not rated, received more than one rating, or for which it appeared that the adults had changed their rating were excluded from the analysis. Tables 6—9 summarize the results. Finally, correlational analyses were performed to determine how the elderly adults' grammaticality judgements were correlated with age, digit spans, etc.

The mean grammaticality ratings for the anaphor sentences are given in Table VI. A four group (college students, 60, 70, 80+ year olds) × two constraint (tensed-clause vs. specified subject) × three construction (subject-raising vs. passive vs. reflexive) × two length (short vs. long) × two grammaticality (grammatical vs. ungrammatical) ANOVA was performed. There were no effects or interactions involving the constraint or construction factors. The four-way interaction of constraint × construction × length × grammaticality was not significant nor was the group × constraint × construction × length × grammaticality interaction. The two-way interaction of length × grammaticality was significant, $F(1, 80) = 102.02$, $p < 0.01$, as was the group × length × grammaticality interaction, $F(3, 80) = 4.77$, $p < 0.01$.

Overall, the raters did not distinguish between the tensed-S and specified-subject constraints nor between subject-raising, passive, and reflexive constructions in evaluating the sentences. For the grammatical sentences, longer ones (M = 3.8) were judged to be less grammatical than the short ones (M = 5.6) by all age groups. Length had no effect on the ratings of the ungrammatical sentences (M = 1.7). The difference between grammatical and ungrammatical sentences and short and long ones decreased sharply with age, contributing to the significant group × length × grammaticality interaction. For the college students, the grammatical-ungrammatical difference was 4.9 points on the 7-point scale for the short sentences, 4.0 points for the long sentences. For the 80-year olds, this difference was only 2.3 points for the short sentences and merely 1 point for the longer sentences. As a result, the 80-year olds could not reliably distinguish long grammatical sentences from ungrammatical ones, $t(10) = 1.25$, $p > 0.10$.

The mean grammaticality ratings for the Wh-sentences are given in Table VII. A four group × two constraint × three construction (question vs. relativized vs. topicalized) × two length × two grammaticality ANOVA was performed. The four-way constraint × construction × length × grammaticality interaction was highly significant, F(2,

TABLE VI
Mean grammatical ratings by the college students and elderly adults for the anaphor sentences.

	Tensed-S constraint							
	Short				Long			
	C	60s	70s	80+	C	60s	70s	80+
Subject-raising								
Grammatical	6.6	6.3	5.8	5.1	5.5	4.0	3.2	2.3
Ungrammatical	1.8	1.6	1.9	2.0	3.7	2.1	1.9	1.0
Passive								
Grammatical	6.3	6.3	6.0	4.9	5.9	3.5	3.4	2.3
Ungrammatical	2.1	1.6	1.8	2.0	2.4	1.5	1.6	1.6
Reflexive								
Grammatical	6.0	6.2	6.0	5.0	5.7	4.4	3.4	2.4
Ungrammatical	1.9	1.8	1.9	1.6	2.4	1.4	1.6	1.3
	Specified-Subject constraint							
	Short				Long			
	C	60s	70s	80+	C	60s	70s	80+
Subject-raising								
Grammatical	6.8	5.7	5.0	4.4	6.1	3.5	3.3	2.7
Ungrammatical	3.0	2.1	2.0	2.2	2.2	2.4	2.1	1.9
Passive								
Grammatical	6.9	6.0	4.9	4.4	5.9	3.5	3.1	2.3
Ungrammatical	1.6	1.6	1.9	1.5	1.8	1.8	1.6	1.9
Reflexive								
Grammatical	5.9	6.9	6.5	5.5	5.2	3.4	3.1	2.7
Ungrammatical	2.2	1.3	2.2	1.9	1.9	2.0	2.1	1.3

160) = 37.01, $p < 0.01$, as was the group × constraint × construction × length × grammaticality interaction, $F(6, 160) = 5.41$, $p < 0.01$.

Whereas the college students were not affected by constraint, rating grammatical conjoined-NP sentences and Complex NP sentences alike

TABLE VII
Mean ratings by the college students and elderly adults for the WH-sentences.

	Conjoined-NP constraint							
	Short				Long			
	C	60s	70s	80+	C	60s	70s	80+
Question								
Grammatical	5.0	4.6	4.1	3.5	5.6	4.2	3.1	2.2
Ungrammatical	1.8	1.8	1.7	1.9	1.6	1.6	1.5	1.5
Relativized								
Grammatical	6.1	4.4	4.1	3.0	4.9	3.6	3.0	3.0
Ungrammatical	1.7	1.6	1.6	1.7	1.4	1.4	1.4	2.1
Topicalized								
Grammatical	3.1	3.3	2.7	2.5	3.1	2.7	1.8	1.5
Ungrammatical	1.8	1.8	1.3	1.5	1.9	2.1	1.1	1.9
	Complex NP constraint							
	Short				Long			
	C	60s	70s	80+	C	60s	70s	80+
Question								
Grammatical	5.3	2.8	1.8	1.2	4.0	2.0	1.3	1.1
Ungrammatical	1.1	1.5	1.9	1.1	1.3	1.5	1.3	1.2
Relativized								
Grammatical	5.3	3.2	3.2	2.7	4.0	2.2	1.7	1.5
Ungrammatical	1.9	1.5	1.2	1.5	1.6	1.7	1.6	1.5
Topicalized								
Grammatical	5.8	3.7	3.0	2.4	3.7	2.3	1.8	1.5
Ungrammatical	1.3	1.1	1.5	1.3	1.5	1.9	1.5	1.5

(short: M = 5.1; long: 4.2), the older adults rated the Complex NP sentences (short: M = 2.7; long: M = 1.7) as significantly less grammatical than the conjoined-NP sentences (short: 4.3; long: M = 3.1). Constraint had no effect on the ratings for the ungrammatical sentences. The college students and the older adults rated the grammatical topicalized sentences (short: M = 3.3; long: M = 2.3) as less grammati-

TABLE VIII
Mean ratings by the college students and elderly adults for the relative clause sentences.

Right-Branching

	Short				Inserted Phrase				Inserted Clause			
	C	60s	70s	80+	C	60s	70s	80+	C	60s	70s	80+
Object relative												
Grammatical	6.2	6.4	5.9	4.3	4.7	2.5	2.2	2.1	4.3	1.5	1.5	1.4
Ungrammatical	1.7	1.8	1.6	1.1	1.7	1.9	1.4	1.8	1.4	1.6	1.4	1.8
Subject relative												
Grammatical	6.9	6.9	6.8	5.2	4.4	2.3	1.9	1.9	3.5	1.4	1.7	1.0
Ungrammatical	1.3	1.6	1.5	1.7	1.3	1.5	1.5	1.6	1.1	1.6	1.4	1.8

Left-branching

	Short				Inserted Phrase				Inserted Clause			
	C	60s	70s	80+	C	60s	70s	80+	C	60s	70s	80+
Object relative												
Grammatical	6.3	3.4	2.9	2.4	4.2	2.2	1.7	2.2	4.2	2.1	1.6	1.7
Ungrammatical	1.7	1.8	1.3	1.0	1.5	1.7	1.5	1.6	1.9	2.1	1.3	1.4
Subject relative												
Grammatical	5.8	3.3	2.8	2.1	5.2	1.9	1.8	2.1	4.1	2.7	1.9	1.8
Ungrammatical	1.5	1.3	1.3	1.5	1.7	1.7	1.6	1.8	1.3	1.6	2.1	1.7

TABLE IX
Mean ratings by the college students and elderly adults for the other grammatical and ungrammatical sentences for experiment.

	Short				Long			
	C	60s	70s	80+	C	60s	70s	80+
Grammatical	6.5	6.3	5.8	4.2	5.8	6.1	5.6	4.0
Ungrammatical	1.5	1.3	1.5	1.6	1.8	1.3	1.1	1.5

cal than the grammatical questions and relativized sentences (short: M = 4.2; long: M = 3.0). Construction had no effect on the ratings for the ungrammatical sentences. Long grammatical sentences (M = 2.4) were rated as less grammatical than short ones (M = 3.5) whereas length had no effect on the ratings for the ungrammatical sentences (M = 1.4).

The differences between the conjoined-NP and Complex NP sentences, the three sentence constructions, the long and short sentences, and the grammatical and ungrammatical sentences decreased sharply with the age of the raters. The 80-year-olds were unable to distinguish grammatical from ungrammatical sentences and gave similar ratings to all of the different types of sentences (M = 1.6), all $t(10) < 1.8$, $p > 0.05$, resulting in the significant five-way interaction.

A signal detection analysis (Green and Swets, 1966) was performed using only the sentences actually rated as grammatical, e.g., assigned ratings of 5, 6 or 7. For each subject, the proportion of grammatical sentences rated as grammatical (HITS) and the proportion of the ungrammatical sentences rated as grammatical (FALSE ALARMS) were computed. From these proportions, d′, a measure of sensitivity to the contrast between grammatical and ungrammatical sentences, and β, a measure of bias to respond 'grammatical,' were then computed for each subject. Larger d's indicate a greater sensitivity to the contrast in grammaticality between HITS and FALSE ALARMS; larger βs indicate a greater bias to guess that the sentences are grammatical. These measures are reported in Table X. A four group × two length MANOVA was performed. For the *d*'s, there was a significant two-way interaction, $F(3, 80) = 5.11$, $p < 0.05$, showing that the *d*'s mirrored the ratings' data. In the analysis of the βs, there were no significant effects and the interaction was not significant. This indicates that the age groups did not differ in their bias, or tendency to guess that the sentences were grammatical.

A series of correlations were also computed between the elderly adults' ratings of the the grammatical sentences and their age, digit span scores, vocabulary scores, and years of education. Only the data from 47 subjects who had participated in the earlier experiment was used in this analysis. To facilitate the analysis, the grammatical ratings were averaged for the different constructions and sentence lengths. As shown in Table XI, the adults' age was negatively correlated with their ratings,

TABLE X
Age group differences in d' and β for the grammatical sentences in experiment.

	College		60s		70s		80+	
	d'	β	*d'*	β	*d'*	β	*d'*	β
Short sentences	2.1	3.0	1.9	2.9	1.6	2.8	1.2	3.0
Long sentences	2.2	3.1	1.8	3.0	1.5	3.0	1.2	3.1

indicating the 80-year-olds found these sentences to be less grammatical than the 60- and 70-year-olds. Further, the ratings were positively correlated with the adults' digit span scores, indicating that adults with smaller digit spans rated the sentences as less grammatical than those with larger digit spans. Vocabulary scores and years of education were not significantly correlated with the grammaticality ratings.

TABLE XI
Corelations between grammatical ratings and the elderly adults' age, education and WAIS subscales for the sentences used in experiment.

	AGE	Education	Digits Forward	Digits Backward	Vocabulary
Anaphor sentences					
Tensed-S	0.48**	+0.11	+0.21*	+0.52**	0.07
Specified-Subject	−0.35**	+0.08	+0.18	+0.48**	−0.02
Complex NP sentences					
Conjoined-NP	−0.29*	+0.14	+0.11	+0.45**	+0.11
Complex NP	−0.59**	−0.09	+0.25*	+0.65**	+0.06
Relative Clause sentences					
Right-branching	−0.41**	+0.02	+0.15	+0.52**	+0.12
Left-branching	−0.62**	−0.12	+0.22*	+0.61**	−0.02
Other sentences	−0.32*	+0.06	+0.21*	+0.32**	+0.14

* $p < 0.05$,
** $p < 0.01$

The results confirm those from an earlier experiment and suggest that adults of all ages are able to detect rule violations. The elderly adults were able to detect sentences violating the tensed-S, specified-subject, conjoined-NP and Complex NP constraints. The elderly adults were also able to detect filled gaps in relative clause sentences and to detect missing constituents in other sorts of sentences. The adults' grammaticality ratings were independent of their vocabulary size or educational background suggesting that syntactic judgements arise from exposure to English in every day conversational settings rather than formal instruction.

The elderly adults assigned lower ratings to many of the grammatical sentences, especially those which were long or complex, including: long sentences with anaphors, and both short and long Wh-island sentences which involve two levels of sentence embedding. There is good reason to believe that these reflect performance limitations rather than a loss of linguistic competence. The elderly adults judged short, simple sentences, including the short anaphor sentences, to be grammatical although there was an age-related decline in these ratings. With the exception of the Complex NP sentences, the ratings for the technically grammatical sentences are higher than those for the technically ungrammatical sentences. Interestingly, the older adults judged the grammatical Complex NP sentences to be ungrammatical while accepting the grammatical conjoined-NP sentences.

This research was initiated as a way of testing whether elderly adults have intact linguistic competence despite severe performance limitations on their production and processing of complex sentences. The effects of working memory limitations on adults' production and processing of complex syntactic structures are robust. Not only are elderly adults unlikely to spontaneously produce multi-clause sentences, especially those with left-branching structures, but they are unable to process such sentences when asked to evaluate grammaticality.

Three alternative interpretations are possible: First, it may be that linguistic competence is preserved across the life-span but that performance limitations affect even grammaticality judgements. Under this scenario, syntactic complexity should affect rated grammaticality but grammatical and ungrammatical sentences should still be distinguished. Second, it may be that linguistic competence, as revealed by the grammaticality judgement task, also changes with age in that grammatical rules come to be governed by additional constraints prohibiting

multiple embeddings and left-branching structures. If so, complex sentences, subject to these additional constraints, should be judged to be ungrammatical and their ratings should be indistinguishable from those for other ungrammatical sentences. Third, the distinction between competence and performance may be discarded since competence cannot be isolated from performance even through the use of grammaticality judgement tasks. This interpretation suggests that syntactic complexity should affect ratings for both grammatical and ungrammatical sentences.

The findings support the first alternative, that adults' linguistic competence remains intact across the life-span, in so far as elderly adults in their 70s and 80s are able to recognize many different types of ungrammatical sentences. Syntactic complexity affected only the ratings for the grammatical sentences which were, in general, distinguished from the ungrammatical ones although some long or complex grammatical sentences were rated as ungrammatical by the elderly adults.

The findings also suggest that even judgements of sentence grammaticality are subject to performance limitations on the processing of long and complex sentences. The age-related declines in rated grammaticality and the age × length and age × complexity interactions which were obtained suggest that elderly adults are unable to process multiple syntactic constituents simultaneously due to working memory limitations. This interpretation is supported by the finding that grammatical judgements are negatively correlated with the adults' age but positively correlated with their backwards digit span, a measure of working memory capacity. It appears that the elderly adults assigned low ratings both to those sentences in which they detected rule violations and to those which they were unable to process.

This finding has implications for models of language development. A common theme in current developmental psycholinguistics is the hypothesis that children's acquisition of grammar is characterized not by the gradual accumulation of more and more syntactic rules, but by the abrupt resetting of linguistic parameters (Hyams, 1986; Roeper and Williams, 1987) or the restructuring of linguistic rule systems (Bowerman, 1985, 1987). The results of the present study suggest that once fixed, these aspects of the childs' or adults' grammar cannot be reset in order to accommodate performance limitations such as changes in the capacity of working memory. Hence, performance decrements will result whenever the grammar, or the adults' linguistic competence, conflicts with such limitations. In the present case, evidence for such a conflict comes from the finding that elderly adults judge sentences to be ungrammatical either because the sentences violate formal syntactic constraints or because the sentences are long and complex, hence, difficult to process.

NOTE

* This research was supported by grant R01AG06319 from the National Institute on Aging to S. Kemper.

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BOUNDING RIGHTWARD Ā-DEPENDENCIES*

This paper analyzes two sorts of rightward Ā-dependencies, both of which have traditionally been thought to involve 'movement', or the association of a gap to an antecedent for the purposes of thematic interpretation. (By thematic interpretation I mean to include both argument and adjunct functions.) The first of these is exemplified in the Extraposition constructions in (1)—(4). The second consists of the constructions in (5).

(1) (a) A man came into the room who everybody recognized.
(b) Mary was talking to a man at the party who everyone knew.
(c) A woman appeared at the door with blond hair.
(d) The construction has just begun of a new bridge over the bay.

(2) (a) So many people came to the party that we left.
(b) Mary invited so many people to the party that we were upset.

(3) (a) More people came to the party than I invited.
(b) Mary invited more people to the party than John invited.

(4) (a) Pictures of more candidates were taken than I expected.
(b) He invited more people to the party than John expected.

(5) (a) There walked into the room a man with long blond hair.
(b) John bought for his mother a painting that he liked.

Helen Goodluck and Michael Rochemont (eds.), Island Constraints, 373—397.